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(54) [Title of the Invention] WATER PIPE HAVING COATED INNER SURFACE  
AND PRODUCTION METHOD THEREFOR

(57) [Abstract]

[Object] To provide a water pipe capable of preventing environmental  
hormones from entering tap water while maintaining the good adhesion to  
the inner surface of the water pipe and corrosion resistance of a  
coating film.

[Means for Solving the Problem] A water pipe having a coated inner  
surface, comprising a water pipe unit, an epoxy resin coating layer  
formed on the inner surface of the water pipe unit, and an acrylic resin  
coating layer or polyester resin coating layer formed on the surface of  
the epoxy resin coating layer; and a method for producing a water pipe  
having a coated inner surface, the method comprising the steps of  
applying an epoxy resin powder coating composition to the inner surface  
of a water pipe, and applying an acrylic resin powder coating  
composition or polyester resin powder coating composition to the epoxy  
resin powder coating layer.

[Claims]

[Claim 1] A water pipe having a coated inner surface, comprising a water pipe unit, an epoxy resin coating layer formed on the inner surface of the water pipe unit, and an 5 acrylic resin coating layer or polyester resin coating layer formed on the surface of the epoxy resin coating layer.

[Claim 2] A method for producing a water pipe having a coated inner surface, the method comprising the steps of 10 applying an epoxy resin powder coating composition to the inner surface of a water pipe, and applying an acrylic resin powder coating composition or polyester resin powder coating composition to the epoxy resin powder coating layer.

15 [Detailed Description of the Invention]

[0001]

[Field of Industrial Application] The present invention relates to an inner-surface-coated water pipe and a production method therefor. In particular, the present 20 invention relates to an inner-surface-coated water pipe for use in providing safe tap water, the inner surface of which is coated to have two coating layers, with the overcoat layer being composed of a coating layer that has no risk of contaminating tap water; and a production 25 method therefor.

[0002]

[Prior Art] Cast-iron pipes and electric-resistance-welded pipes have been used as water pipes. The inner surfaces of such pipes easily rust and are thus furnished 5 with a coating composition as an anticorrosive. Epoxy resin coating compositions have been used in the form of solventless coating compositions or powder coating compositions as such coating compositions due to their good adhesion to the substrate and corrosion resistance. 10 [0003] However, when epoxy resin coating compositions are coated and then cured, unpolymerized bisphenol A remains in the coating layer; bisphenol A is an environmental hormone. Therefore, epoxy resin coating compositions have recently been considered problematic in that they 15 adversely affect the human body because unpolymerized bisphenol A leaches out into tap water.

[0004]

[Problems to Be Solved by the Invention] However, since among a variety of coating compositions epoxy resin 20 coating compositions have excellent adhesion to the inner surface of water pipes, superior corrosion resistance, and like characteristics, it is currently not very beneficial to use other coating compositions for application to the inner surface of water pipes. 25 [0005] The present invention provides a water pipe that

can prevent environmental hormones from entering tap water while maintaining the good adhesion and corrosion resistance by applying as an undercoat an epoxy resin coating composition to the inner surface of a water pipe 5 and applying as an overcoat an acrylic resin coating composition or polyester resin coating composition; and a production method therefor.

[0006]

[Means for Solving the Problems] The inventors found that 10 the problem of environmental hormones entering tap water can be solved while maintaining the good adhesion and corrosion resistance by creating on the inner surface of a water pipe a two-layer structure composed of an undercoat layer to give corrosion resistance to the water pipe and 15 an overcoat layer to prevent hazardous substances contained in the undercoat layer from entering tap water, and thereby accomplished the present invention.

[0007] The inner-surface-coated water pipe of the 20 invention comprises a water pipe unit, an epoxy resin coating layer formed on the inner surface of the water pipe unit, and an acrylic resin coating layer or polyester resin coating layer formed on the surface of the epoxy resin coating layer. The method for producing an inner-surface-coated water pipe of the invention comprises the 25 steps of applying an epoxy resin powder coating

composition to the inner surface of a water pipe, and applying an acrylic resin powder coating composition or polyester resin powder coating composition to the epoxy resin powder coating layer.

5 [0008]

[Mode for Carrying Out the Invention] The present invention is described below in detail. In the present invention, any conventional solid resin of bisphenol A-type having a softening temperature of at least 60°C and an epoxy equivalent of at least 500 can be used as the resin component of the coating composition for forming the epoxy resin coating layer, i.e., the undercoat layer, and may be partially modified by replacement with a novolac-type epoxy resin, cresol novolac-type epoxy resin, phenol novolac-type epoxy resin, alkylphenol novolac-type epoxy resin, etc. Such epoxy resins can be used singly or in combination. Moreover, such epoxy resins can be used in combination with polyester resins and acrylic resins that have a carboxyl group within the resin molecule. Blocked isocyanate resins, polyfunctional carboxylic acids, polyfunctional acid anhydrides, dicyandiamine, imidazoles, etc., can be used concomitantly as curing agents.

[0009] In addition to such resins and curing agents, it is effective to use coloring pigments and antirust pigments as coating film components to enhance the strength,

corrosion resistance, and the like of the film; additives to impart other characteristics; etc. Examples of coloring pigments include yellow iron oxide, titanium yellow, red iron oxide, titanium oxide, like inorganic 5 pigments; permanent yellow FGL, phthalocyanine blue, indanthrene blue RS, permanent red F5RK, brilliant first scarlet G, and like organic pigments; etc. The amount of coloring pigment in the resin particles is usually about 0.5% to about 60% in PWC. Coloring pigments need not be 10 used in the case of clear coating compositions.

[0010] PWC herein refers to pigment weight concentration and can be calculated using the following equation:  
PWC = [(Contained pigment in weight percent) / (Total  
solids content of coating composition in weight percent)]  
15 x 100

When the amount of pigment is excessive, and especially when the amount of pigment with high oil absorbency is excessive, the resulting coating film formed from such a coating composition is likely to have an impaired 20 smoothness.

[0011] Moreover, barium sulfate, barium carbonate, calcium carbonate, clay, silica powder, silicic acid fine powder, diatomaceous earth, talc, basic magnesium carbonate, alumina white, etc., can be added as extender pigments to 25 control the gloss level and hardness of the coating film.

[0012] Flaky pigments may be added to enhance the strength and corrosion resistance of the coating film. Aluminium pigments, mica pigments, metal powders, flaky glass powders, plastic film pieces, etc., can be used as flaky pigments. Such pigments can be used singly or as a combination of two or more kinds. In particular, adding glass flakes, mica pigments, or metal powdery pigments as fine flaky pigments is more effective in enhancing corrosion resistance than adding extender pigments

5 although the material costs of the coating composition are likely to be increased accordingly.

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[0013] In the present invention, the overcoat layer is formed to prevent leaching of hazardous substances from the undercoat epoxy resin coating layer. Thus, it is necessary to form, as the overcoat layer, a coating film containing no hazardous substances at all. Accordingly, in the present invention, an acrylic resin coating composition or polyester resin coating composition is used to form an overcoat layer for coating the inner surface of water pipes. In the production of the acrylic resin for use in the overcoat layer, materials that are suspected of being environmental hormones, such as styrene monomers, cannot be used. For the same reason, triphenyl tin, tributyl tin and the like cannot be used as a

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polymerization catalyst in production of the polyester

resin. Further, diethyl phthalate and the like cannot be used as a plasticizer. Therefore, the coating composition for use in the present invention for forming the overcoat layer is prepared without using such materials, catalysts 5 or additives and by using materials that have no risk of producing hazardous substances during the polymerization reaction.

[0014] Examples of acrylic monomers for use in production of the acrylic resin include methyl acrylate, ethyl acrylate, n-propyl acrylate, i-propyl acrylate, n-butyl acrylate, i-butyl acrylate, sec-butyl acrylate, t-butyl acrylate, 2-ethylhexyl acrylate, lauryl acrylate, tridecyl acrylate, stearyl acrylate, cyclohexyl acrylate, benzyl acrylate, tetrahydrofurfuryl acrylate, 2-hydroxyethyl acrylate, 2-hydroxypropyl acrylate, 2-methoxyethyl acrylate, 2-ethoxyethyl acrylate, 2-butoxyethyl acrylate, 2-phenoxyethyl acrylate, ethylcarbitol acrylate, allyl acrylate, glycidyl acrylate, dimethylaminoethyl acrylate, acrylic acid, sodium acrylate, trimethylolpropane acrylate, 20 1,4-butanediol diacrylate, 1,6-hexanediol acrylate, neopentyl glycol diacrylate, pentaerythritol triacrylate and like acrylic acid and acrylic ester monomers; and methyl methacrylate, ethyl methacrylate, butyl methacrylate, isobutyl methacrylate, t-butyl methacrylate, 25 2-ethylhexyl methacrylate, lauryl methacrylate, tridecyl

methacrylate, stearyl methacrylate, cyclohexyl  
methacrylate, propyl methacrylate, benzyl methacrylate,  
isopropyl methacrylate, sec-butyl methacrylate, 2-  
hydroxyethyl methacrylate, 2-hydroxypropyl methacrylate,  
5 dimethylaminoethyl methacrylate, diethylaminoethyl  
methacrylate, glycidyl methacrylate, tetrahydrofurfuryl  
methacrylate, allyl methacrylate, ethylene glycol  
methacrylate, triethylene glycol methacrylate,  
tetraethylene glycol methacrylate, 1,3-butylene glycol  
10 methacrylate, trimethylolpropane methacrylate, 2-  
ethoxyethyl methacrylate, 2-methoxyethyl methacrylate,  
dimethylaminoethyl methyl chloride salt methacrylate,  
methacrylic acid, sodium methacrylate and like methacrylic  
acid and methacrylic ester monomers. In addition to such  
15 acrylic monomers, acrylamide, acrylonitrile, vinyl acetate,  
ethylene, propylene, isobutylene, butadiene, isoprene,  
chloroprene and like vinyl monomers can be used as  
copolymerization components.

[0015] Other usable copolymerization components include  
20 epoxy-containing ethylenically unsaturated monomers,  
carboxy-containing ethylenically unsaturated monomers,  
hydroxy-containing ethylenically unsaturated monomers, etc.  
Examples of epoxy-containing ethylenically unsaturated  
monomers include glycidyl (meth)acrylate, methylglycidyl  
25 (meth)acrylate, allylglycidyl ether, 3,4-

epoxycyclohexylmethyl (meth)acrylate, etc. Examples of carboxyl-containing ethylenically unsaturated monomers include (meth)acrylic acid, crotonic acid, itaconic acid, maleic acid, fumaric acid, etc. Examples of hydroxy-  
5 containing ethylenically unsaturated monomers include hydroxyethyl methacrylate, 2-hydroxypropyl methacrylate, etc.

[0016] The polymerization for producing the acrylic acid for use in the present invention can be carried out by a  
10 process in which, after synthesizing a high-molecular-weight resin by a conventional solution polymerization procedure, the solvent is removed and collected by thin-film heating-decompression or like method to prepare a solid resin; or by a process in which, after synthesizing  
15 a resin by a suspension polymerization procedure, the moisture is removed by spray-drying or like method to prepare a solid resin.

[0017] When the reactive polar group in the acrylic resin is a glycidyl group, a multifunctional carboxy-containing  
20 compound such as sebacic acid, dodecanedicarboxylic acid, etc., a multifunctional acid anhydride or the like can be used as a curing agent for the acrylic resin. When the reactive polar group in the acrylic resin is a hydroxy group or a combination of a hydroxy group and a carboxy  
25 group, a blocked isocyanate resin, melamine resin or the

like can be used as a curing agent. Examples of blocked isocyanate resins include isocyanate resins obtained by adding, to trimethylol propane, an isocyanate monomer such as hexamethylene diisocyanate, isophorone diisocyanate,

5      hydrogenated xylene diisocyanate, toluene diisocyanate or the like; and blocked isocyanate resins obtained by blocking multifunctionalized isocyanate resins or hydrogenated multifunctionalized isocyanate resins with caprolactone or an oxime.

10     [0018] When using a blocked isocyanate resin as a curing agent, in order to ensure the stability of resin particles in the powder coating composition, blocked isocyanate resins that are by themselves able to solidify are preferable, and blocked isocyanate resins obtained by

15     blocking, with  $\epsilon$ -caprolactam, resins prepared from isophorone diisocyanate, and like resins are preferable. However, liquid curing agents can be used while adjusting their amounts of addition and the amount of pigment to be added, or by combining them with a resin having a high

20     glass transition temperature, such as an acrylic resin, polyester resin or the like.

25     [0019] The following is a description of the polyester resin coating composition. Examples of carboxylic acid components forming the polyester resin include terephthalic acid, isophthalic acid, phthalic acid,

naphthalenedicarboxylic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, 1,9-nonanedicarboxylic acid, 1,10-decanedicarboxylic acid, 1,12-dodecanedicarboxylic acid,  
5 1,2-octadecanedicarboxylic acid, eicosanedicarboxylic acid, maleic acid, fumaric acid, cyclohexanedicarboxylic acid, hexahydrophthalic acid, tetrahydrophthalic acid, trimellitic acid, pyromellitic acid and like polyvalent carboxylic acids, and lower alkyl esters and anhydrides  
10 thereof; malic acid, tartaric acid, 1,2-hydroxystearic acid, paraoxybenzoic acid and like hydroxycarboxylic acids; etc.

[0020] Examples of usable alcohol components include ethylene glycol, diethylene glycol, triethylene glycol, 15 1,2-propanediol, 1,3-propanediol, 1,3-butanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, 1,9-nonanediol, 1,10-decanediol, neopentyl glycol, spiroglycol, 1,10-decanediol, 1,4-cyclohexane dimethanol, 2,2,4-trimethylpentane-1,3-diol, trimethylolethane,  
20 trimethylolpropane, glycerin, pentaerythritol, etc.

[0021] The polyester resin for use in the present invention can be produced, for example, by a conventional process for producing polyester resins for powder coating compositions, using, as raw materials, an acid component 25 and alcohol component as mentioned above. For example, a

polyester resin can be produced by a process in which such raw materials are suitably combined and subjected to an esterification or ester exchange reaction by a standard method at 200 to 280°C, and after reducing the pressure to 5 5 hPa or lower, a polycondensation reaction can be performed at 230 to 290°C in the presence of a catalyst to obtain a resin with a high degree of polymerization, which is then subjected a depolymerization reaction with an alcohol component. The polyester resin preferably has 10 a softening temperature of 50 to 150°C. When the softening temperature is lower than 50°C, the resulting powder coating composition is susceptible to blocking and difficult to handle. When the softening temperature is higher than 150°C, the smoothness and continuity of the 15 coating film are impaired during the film-forming step after application of the coating composition, eliminating the effect of intercepting hazardous substances leaching out from the undercoat layer.

[0022] It is preferable to use a blocked isocyanate resin 20 as mentioned above for crosslinking and curing the polyester resin. In such a case, the ratio of hydroxy groups in the polyester resin to latent isocyanate groups in the blocked isocyanate resin which contribute to the reaction, i.e., NCO/OH ratio, is preferably from 0.6 to 25 1.2, and more preferably from 0.8 to 1.0.

[0023] The epoxy resin coating layer, acrylic resin coating layer or polyester resin coating layer on the inner surface of a water pipe of the present invention can be formed using a powder coating composition, aqueous dispersion powder coating composition, non-solvent coating composition, electrodeposition coating composition or the like. It is preferable to use a powder coating composition from the viewpoint of application workability and film performance. Epoxy resin powder coating compositions, acrylic resin powder coating compositions and polyester resin powder coating compositions that are preferably usable in the present invention can be prepared by conventional production processes for powder coating compositions.

[0024] In the step of mixing raw materials used as film components and thereby forming a blend, a solid resin material as a main ingredient, a coloring pigment, curing agent, additives, and optionally a small amount of liquid material are mixed as homogeneously as possible. For this purpose, conventional apparatuses for mixing raw materials are usable, such as flush mixers, screw mixers, conical blenders, V mixers, tumbling mixers, jet mixers, kneaders, ribbon mixers, etc.

[0025] Apparatuses usable for melting and kneading include roll mills, screw kneaders, mullers, kneaders, etc. It is

preferable to use an apparatus that makes it possible for the molten and kneaded product to be promptly discharged from the apparatus and cooled. In particular, when the resin particles of the powder coating composition contain 5 a curing agent, the resin component, curing agent and other components are homogeneously mixed in the melting and kneading step. At that time, the blend is heated to the softening temperature of the resin component or higher, and thus a prolonged residence time during kneading causes 10 part of the resin component to react with the curing agent. When such partially reacted resin particles are used for coating, it is likely that the resulting coating film is not smoothly continuous or has defects such as lacking gloss. Accordingly, it is preferable to use an apparatus 15 in which the feed is supplied from one side and the molten and kneaded product is continuously discharged from another side. The molten and kneaded product is cooled and then pulverized with a grinding and classifying machine to obtain a powder with a predetermined particle 20 size distribution. The surface of this powder is post-treated with a fluidizing agent or the like to obtain a powder coating composition.

[0026] In the present invention, the inner surface of the water pipe can be coated by causing a powder coating 25 composition to be carried by an air flow from one end of a

water pipe; by inserting a powder coating gun inside the water pipe and coating the inner surface while withdrawing the gun; or other methods. Also, the devices for applying the undercoat and overcoat layers can be inserted in the 5 water pipe concurrently to apply undercoat and overcoat layers substantially simultaneously with only a short interval, thereby forming coating films.

[0027] Coating methods usable in the present invention include a method in which, after pretreatment, an 10 undercoat layer powder coating composition is applied to a water pipe that has been preheated to a temperature not lower than the resin softening temperature in a preheating oven or induction heating apparatus, and then an overcoat layer powder coating composition is applied to the lower 15 layer powder coating composition in a melted state while being formed into a film, followed by curing the two layers simultaneously to form films; and a method in which an undercoat layer powder coating composition is applied to a water pipe at room temperature and heated to form a 20 completely cured film of the undercoat layer powder coating composition, and then an overcoat layer powder coating composition is applied by the same procedure to form a film.

[0028] When the water pipe is preheated to a temperature 25 not lower than the resin softening temperature, it is

usually preferable that the preheating temperature be about 200°C to 250°C. This is because a preheating temperature lower than 200°C is likely to produce a temperature variation over the pipe surface, which leads 5 to inhomogeneous curing and crosslinking of the powder coating composition applied, failing to exhibit film performance; and a preheating temperature higher than 250°C is uneconomical since water pipes have a large heat capacity and need a great deal of energy to be heated to 10 such a temperature.

[0029] Specific coating methods usable in the present invention include the following:

- (i) a method in which an undercoat layer coating composition is applied to the inner surface of a preheated 15 water pipe, and then melted and formed into a film in a completely or partially cured state, and an overcoat layer coating composition is applied thereon and cured;
- (ii) a method in which an undercoat layer coating composition is applied to the inner surface of a preheated 20 water pipe, and an overcoat layer coating composition is then applied to the lower layer coating composition in a partially or completely molten state, to form a film;
- (iii) a method in which an undercoat layer coating composition is applied to the inner surface of a water 25 pipe at room temperature and heated for melting, and

before the temperature drops, an overcoat layer powder coating composition is applied so that the two layers are cured simultaneously by the residual heat; and

5 (iv) a method in which, in process (iii), the two layers are further heated for curing during the simultaneous curing.

[0030] The method for producing an inner surface-coated water pipe may further comprise applying a clear coating composition after the application of the overcoat layer 10 coating composition, i.e., the acrylic resin powder coating composition or polyester resin powder coating composition.

[0031]

[Examples] The present invention is described below in 15 further detail with reference to Production Examples and Examples. In these Production Examples and Examples, parts are expressed on a weight basis.

<Production of an undercoat layer powder coating composition> A polyester resin (32 parts) having a 20 softening temperature of 120°C and an acid value of 45, a bisphenol A-type epoxy resin (32 parts) having an epoxy equivalent of 910, a titanium pigment (20 parts), talc (10 parts), a surface modifier (5 parts), and a curing accelerator (1 part) were mixed using a screw mixer and 25 rendered homogeneous using a flash mixer.

[0032] A twin-screw kneader was used as a melt-kneading machine with the heating temperature being set at 115°C. A twin-roller cooler that can be used for cool-rolling was provided on top of the melt-kneading machine, and a hammer 5 crusher was provided on top of the cooler. The homogenously mixed material was supplied from a feeder of the twin-screw kneader. The mixture was homogenized after about 20 seconds of residence and knead-dispersion. This homogenized substance was dropped as a viscous liquid of 10 about 120°C from the top of the twin-screw kneader to reduction rolls of the twin-roller cooler, rolled, cooled in about 10 seconds to almost room temperature, and the thus-obtained platy resin particulate material was preliminarily crushed to coarse powder resin particles 15 having a diameter of about 0.5 mm using a hammer crusher.

[0033] The preliminarily crushed coarse powder was continuously pulverized using a turbo grinder, and classified using a 120 mesh classifier. Colloidal silica (0.8 parts) and the resin particles which had been 20 classified were homogeneously mixed and subjected to a post-treatment, obtaining an undercoat layer powder coating composition.

[0034] <Production of overcoat layer powder coating composition 1> In a dropping vessel were homogeneously 25 dissolved 60 parts of methyl methacrylate, 6 parts of

butyl acrylate, 33 parts of glycidyl methacrylate, and 1 part of azoisobutyronitrile. Xylol (100 parts) was placed in a reaction vessel and heated to 120°C. While stirring this reaction vessel, the solution in the dropping vessel 5 was added to the reaction vessel dropwise over one hour and the resultant was left for two hours. Thereafter, 0.3 parts of azoisobutyronitrile was further added thereto, the resultant was left at 150°C for about 4 hours to proceed a polymerization reaction, obtaining a resin 10 solution.

[0035] This resin solution was treated with a thin-film decompression dryer to remove the solvent, obtaining a solid acrylic resin. The softening temperature of this acrylic resin was about 55°C and molecular weight thereof 15 was about 7000. This acrylic resin (77 parts), dodecanedicarboxylic acid (19 parts), a surface modifier (1 part) and a fluidizing agent (3 parts) were mixed. The mixture was melt-kneaded, pulverized, classified, and subjected to a post-treatment in the same manner as the 20 above-described production of an undercoat layer powder coating composition, obtaining overcoat layer powder coating composition 1.

[0036] <Production of overcoat layer powder coating composition 2> Fifty-six parts of a polyester resin 25 (manufactured by Dainippon Ink and Chemicals, Incorporated,

product name: Finedic M8023, softening temperature of 110°C, hydroxyl value of 40), 11 parts of a block isocyanate resin (manufactured by Daicelhuls, Ltd., product number: IPDI-B1530), 1 part of a surface modifier, 5 2 parts of a fluidizing agent, 29 parts of titanium oxide, and 1 part of carbon black were mixed. The mixture was melt-kneaded, pulverized, classified, and subjected to a post-treatment in the same manner as the above-described production of an undercoat layer powder coating 10 composition, obtaining overcoat layer powder coating composition 2.

[0037] <Production of overcoat layer powder coating composition 3> The acrylic resin obtained in the above-described production of overcoat layer powder coating 15 composition 1 (77 parts), dodecanedicarboxylic acid (19 parts), a surface modifier (1 part), and a fluidizing agent (3 parts) were mixed, melt-kneaded, pulverized and classified, obtaining resin particles for acrylic resin clear powder coating composition. To 93 parts of these 20 resin particles was dry-blended 6 parts of an aluminum pigment (particle diameter of 30 µm, aspect ratio of about 10), 1 part of a silica fine powder was added thereto, and the mixture was subjected to a post-treatment, obtaining overcoat layer powder coating composition 3.

25 [0038] <Example 1> A cast iron tube was preliminarily

heated to evaporate and remove oil, etc. When the temperature of this cast iron tube had fallen to 200°C to 220°C, an undercoat layer powder coating composition was supplied from an air flow vessel to an electrostatic 5 powder coating gun, and coating was conducted in such a manner that the film thickness became about 700 µm while withdrawing the coating gun from the cast iron tube.

[0039] Sixty seconds after the application of the undercoat layer powder coating composition, overcoat layer 10 powder coating composition 1 was applied using another electrostatic powder coating gun in such a manner that the thickness of overcoat layer powder coating composition 1 was about 100 µm, the resultant was left for 3 minutes, and cooled using water, obtaining a water pipe with a 15 coated inside. When a cross section of this pipe was observed using a microscope, the layer of the undercoat layer powder coating composition and the clear layer of the overcoat layer powder coating composition formed two separate layers that were not intermixed to each other. Furthermore, when the surface of the coating film was 20 analyzed using FTIR, neither absorption peaks due to the structural formula attributable to bisphenol A nor absorption peaks attributable to the structural formula of the epoxy resin both contained in the undercoat layer 25 powder coating composition were observed. Water was

placed in the coated cast iron tube and left at 40°C for 1000 hours. A microanalysis of the water was conducted and bisphenol A was not detected.

[0040] <Example 2> An electric-resistance-welded pipe was 5 subjected to emulsion degreasing, heated and dried. Coating gun equipment having gun necks longer than the pipe was used. A gun for an undercoat layer powder coating composition and a gun for an overcoat layer powder coating composition were provided on the head of the 10 coating gun equipment 50 cm apart, and the guns were connected to their respective coating composition feeders.

[0041] The coating gun equipment was prepared in such a manner that an undercoat layer powder coating composition was supplied to a gun on the withdrawal-direction and 15 overcoat layer powder coating composition 2 was supplied to a gun on the back side, and cold water was circulated through the supporting part and the coating guns. The electric-resistance-welded pipe was heated in a preheating oven at 250°C, transferred into a coating equipment, and 20 rotated at 200 r.p.m. The coating guns were inserted into the water pipe in such a manner that the top ends of guns emerged from the other end of the pipe, and the coating compositions were immediately sprayed while withdrawing the coating guns at 20 m/min. The undercoat layer and the 25 overcoat layer were coated with a timing difference of

about 1.5 seconds. The coated layers were left for 3 minutes and cooled with water, obtaining a water pipe. When a cross section of this pipe was observed using a microscope, the layer of the undercoat layer powder 5 coating composition and the layer of the overcoat layer powder coating composition formed two separate layers.

[0042] As in Example 1, the surface of the coating film was analyzed using FTIR, and neither absorption peaks due to the structural formula attributable to bisphenol A nor 10 absorption peaks attributable to the structural formula of the epoxy resin both contained in the undercoat layer powder coating composition were observed. Water was placed in the pipe and microanalysis of the water was conducted in the same manner as in Example 1, and 15 bisphenol A was not detected.

[0043] <Example 3> Coating process was conducted in the same manner as in Example 1 except that overcoat layer powder coating composition 3 was used instead of overcoat layer powder coating composition 1, and then evaluated. 20 The results were that bisphenol A was not detected on the surface of the coating film nor in the water in the pipe. Furthermore, the water absorptivity and water permeability of a coating film formed solely of overcoat layer powder coating composition 1, and the water absorptivity and 25 water permeability of the coating film formed solely of

overcoat layer powder coating composition 3 containing flaky pigments were measured. Both the two coating films had a water absorptivity of 0.7% so that no great difference was observed. However, the water permeability 5 of the coating film formed of overcoat layer powder coating composition 3 was half that of the coating film formed of overcoat layer powder coating composition 1, and therefore a significant advantage was observed.

[0044] <Comparative Example 1> A water pipe was prepared 10 following the same method of Example 1 except that an undercoat layer powder coating composition was coated in such a manner that the film thickness was about 800  $\mu\text{m}$  and no overcoat layer powder coating composition was applied. The surface of the coating film was analyzed using FTIR, 15 and absorption peaks due to the structural formula attributable to bisphenol A and absorption peaks attributable to the structural formula of the epoxy resin both contained in the undercoat layer powder coating composition were observed.

20 [0045]

[Effect of the Invention] As described above, the water pipe with a coated inner surface of the present invention can be produced without drastically changing the steps, time, costs, etc., of prior art coating techniques. The 25 present invention can add corrosion resistance to a water

pipe, and prevent hazardous substances from entering tap water.